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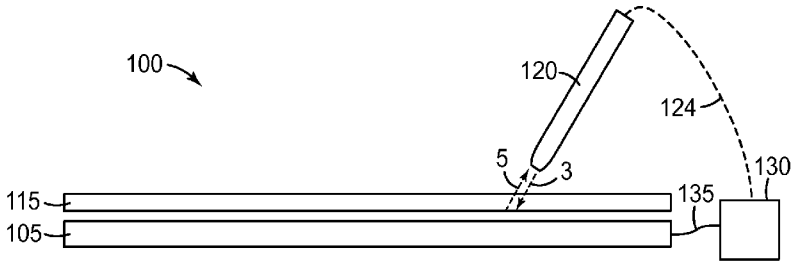

FIG. 1A

(57) Abstract: A digitizer system includes a substrate with indicia having photoluminescent features that uniquely define local areas of the substrate. A sensor device, such as a stylus, may sense radiation emitted from the features, and a controller may determine therefrom the location of the stylus relative to the substrate.

OPTICAL DIGITIZER SYSTEM WITH POSITION-UNIQUE PHOTOLUMINSCENT INDICIA

BACKGROUND

Users are increasingly demanding functionalities beyond merely recognizing a touch to the surface of the touch-sensitive device. Such other functionalities include handwriting recognition and direct note taking (using, for example, a stylus). Such functionalities are generally provided in so-called digitizing systems.

Digitizing systems having position-dependent indicia detected by an image sensor in a stylus are commercially available. Anoto Group AB sells a stylus that detects indicia printed on an opaque paper or cardboard substrate. Reference is made to US Patent Publication No. 2010/0001962 (Doray), which describes a multi-touch display system that includes a touch panel having a location pattern included thereon.

BRIEF SUMMARY OF DRAWINGS

Embodiments described herein may be more completely understood in consideration of the following detailed description in connection with the accompanying drawings, in which:

Figure 1a shows a digitizer and display system.

Figure 1b shows a further embodiment of a digitizer and display system.

Figure 1c shows a further embodiment of a digitizer and display system.

Figure 1d shows an embodiment of a digitizer absent a display system.

Figure 2a shows a magnified drawing of a prior art position-unique indicia pattern.

Figure 2b shows a magnified drawing of a 6x6 position-unique indicia pattern with a plurality of wavelength combinations.

Figure 2c shows a magnified drawing of a 5x5 position-unique indicia pattern with a plurality of wavelength combinations.

Figure 2d shows a filter that could be used conjunction with a position-unique indicia pattern with a plurality of wavelength combinations.

Figure 3a shows a cross section of the end portion of a stylus.

Figure 3b shows a cross section of the end portion of dual-source stylus.

Figure 4a shows a magnified cross section view of a portion of a digitizer and display system.

Figure 4b shows a magnified cross section view of a portion of a digitizer and display system with a dichroic reflector.

Figure 4c shows a magnified cross section view of a portion of a digitizer and display system.

Figure 4d shows a magnified cross section view of a portion of a digitizer and display system.

Figure 4e shows a magnified cross section view of a portion of a digitizer and display system with a minimal overlay.

Figure 4f shows a magnified cross section view of a portion of a digitizer and display system with stylus operating in reflective mode.

Figure 5a shows an exemplary product construction.

Figure 5b shows an exemplary product construction.

Figure 5c shows an exemplary product construction.

Figure 5d shows an exemplary product construction.

Figure 5e shows an exemplary product construction.

Figure 5f shows an exemplary product construction.

In the figures, like reference numerals designate like elements, unless otherwise described.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

A digitizer system is described herein that includes a substrate having photoluminescent indicia that uniquely define an X-Y area of the substrate, and a pen or stylus with optical sensor that sense the indicia and determine based on the sensed indicia the position of the pen relative to the substrate. One pattern of indicia particularly suited to embodiments described herein has been developed by, and is available from, Anoto Company AB, of Sweden. Anoto provides companies the ability to print small, opaque dots on paper in a pattern that uniquely defines the paper. A stylus, that they also provide, is then used to sense portions of the pattern passing within the stylus field-of-view. The sensed pattern is then analyzed and the position of the stylus relative to the paper is computed. Other companies also provide competing patterns, but the concept employed is similar.

The use of photoluminescent indicia, in some embodiments, allows for the substrate and the indicia to be highly light transmissive to human visible light, even to the point of being nearly transparent, such that it is well suited for use as a transparent overlay to be put on a display. Photoluminescent indicia could also be used on non-light-transmissive substrates, including opaque substrates (such as whiteboards or paper).

Photoluminescent indicia also, in some embodiments, may provide improved handling of specular reflection from the substrate. In some embodiments described herein, specular reflections from the substrate (effectively noise) can be more easily filtered out due to the photoluminescent qualities of the indicia. In particular, since photoluminescent indicia, in some embodiments, upon receiving stimulating electromagnetic radiation in a first wavelength range (usually in the form of ultraviolet (UV), visible, or infrared (IR) radiation), the indicia luminescence providing electromagnetic radiation in one or more wavelength ranges different than the stimulating range. Signals associated with specular reflection will mostly be in the wavelength range associated with the stimulating radiation, and thus can be filtered out,

thereby increasing the signal-to-noise ratio in the light received by the sensor from the luminescent indicia.

The material comprising the photoluminescent indicia may be selected based on properties of the substrate, as will be described more fully later. In some embodiments, the material may comprise photoluminescent inks available in the marketplace, or quantum dots (QDs). The photoluminescent material is configured to exhibit photoluminescence; in one embodiment this photoluminescence provided by the indicia is primarily in the infra-red (IR) light wavelengths, and the stimulating radiation is primarily in wavelengths shorter than those associated with IR. There may be some overlap in the light wavelength ranges used to stimulate the indicia as compared with that provided by the luminescence of the material, but in some embodiments less overlap is desirable. The photoluminescent material may be transmissive or transparent to visible light, and may be disposed on a substrate that itself is transmissive or transparent to visible light.

Figure 1a shows stylus digitizer system 100 comprising stylus 120, display 105, digitizer panel 115 patterned with photoluminescent indicia, and electronic controller 130 that controls displayed images via link 135. Controller 130, comprised of various microprocessors and circuitry, controls displayed images via link 135, or it may be communicatively coupled to another display-specific controller that controls displayed images. Display controller 130 receives signals from stylus 120 associated with the position of stylus 120 relative to digitizer panel 115. Controller 130 may also serve as the system processor for a computer system, for example a portable computing system. Though controller 130 is shown as one box in Fig. 1, it may exist as discrete electronic sub-systems, for example, a first sub-system to interact with stylus 120, and a second sub-system to interact with display 105. Stylus 120 is communicatively coupled with controller 130 by link 124. Link 124 may be a bundle of thin wires, but more preferably link 124 is a wireless radiofrequency (RF) link, and in such a construction stylus 120 and controller 130 include radios for back-and-forth communication, or, depending on implementation, one way communication. Such radios in one embodiment implement the Bluetooth™ communications protocol, or that defined by IEEE 802.11.

Stylus 120 has an optical image sensor that can detect patterns of IR light within its field of view (FOV). Stylus 120 detects light 5 emitted from photoluminescent indicia disposed on or within digitizer panel 115. Stylus 120 may provide stimulating radiation in the form of stimulating light 3 to irradiate indicia on digitizer panel 115. In other embodiments, stimulating radiation may come from sources other than those housed within the stylus (for example, LCD backlights and ambient light). Stimulating light 3 has a first wavelength range; indicia emitted light 5 (luminescence) has a second wavelength range. The first and second wavelength ranges in one embodiment do not overlap. In another embodiment the first and

second wavelength ranges minimally overlap such that most of the stimulating radiation energy is at different wavelengths than most of the indicia emitted energy. In another embodiment, the first and second wavelength ranges overlap, but the distribution of intensity (energy) versus wavelength within the range differs between the first and second wavelength ranges. In some embodiments, the second wavelength range of light 5 will comprise a plurality of wavelength combinations that may be discriminated from one another by the optical image sensor in stylus 120. In most cases, indicia are fluorescent or phosphorescent so the first wavelength range will be at shorter wavelengths than the second wavelength range. The breadth of the first and the second wavelength ranges will be based on the nature of the photoluminescent indicia. The first and/or the second wavelength ranges may be beyond those associated with human ocular sensing.

Display 105 may be any type display including but not limited to electronically addressable displays such as liquid crystal displays (LCD), active matrix LCD (AMLCD), organic light emitting diode displays (OLED), active matrix organic light emitting diode displays (AMOLED), electrophoretic display, a projection display, plasma displays, or a printed static image. Display 105 is, in some embodiments, optional, as the digitizer panel 115 may be used in applications where it is opaque.

Digitizer panel 115 is in one embodiment a transparent substrate, such as glass, polyethylene terephthalate (PET), polyethylene naphthalate (PEN) cellulose triacetate (TAC), or any suitable material. It may be fully light transmissive, partially light transmissive, or opaque. Preferably, it is highly light transmissive so as to allow a person to see the output of display 105. Digitizer panel 115 may be one layer or may be comprised of multiple layers of various materials. Digitizer panel 115 includes, disposed upon or within it, photoluminescent indicia that uniquely define the substrate or some portion of the substrate, in two dimensions. Digitizer panel 115 may comprise more than one layer. For example, a durable layer may be used on the top surface. Anti-reflective (AR), anti-glare (AG), polarizing, color filtering, light reflecting, or dichroic optical layers may be included. Touch screen electrodes or resistive surfaces may be included, as well as adhesive layers used to laminate various layers of panel 115. Panel 115 may be rigid or flexible.

Anoto Company AB, of Sweden, licenses software that allows companies to print opaque indicia in the form of ink on, for example, paper. Anoto also sells pens that recognize the indicia and thereby determine the X-Y coordinates of the pen relative to the printed paper.

Figure 2a shows an Anoto type indicium within the solid rectangle, comprising a pattern of opaque dots on a substrate, arranged on a virtual 6x6 matrix indicated by dotted lines. Each intersection of the matrix has one dot, and each dot is position-encoded into one of four positions above, below, left, or right of the

intersection. This provides a coding system based on thirty-six digits of base four, so each 4-some combination of the indicia can represent as many as 4^{36} unique codes. Permutations of codes are reduced to allow independent encoding of X and Y coordinates in each indicium. Permutations are also reduced by the requirement for redundancy that allows determination of the position of a partial surface, and to detect code sequences from any orientation. Even with such reductions, Anoto indicia can encode extremely large areas with position-unique indicia less than 2mm in size, where each of the indicia uniquely define local regions of a substrate.

Photoluminescent indicia described herein may use the same pattern of monochrome dots as used by Anoto, or other options may be preferable. For example, visible light transmissive photoluminescent materials may be used to make features of larger size that still have minimal optical visibility. Larger dots or other feature shapes may be easier to print, and material with larger photoluminescent particles may be used, while indicia size is maintained at less than 2mm square.

Indicia features emitting varying wavelengths of light provide additional coding alternatives. The base four coding system described above can be achieved with four wavelength combinations instead of four-quadrant dot placements or four symbol shapes. An example is shown in Fig. 2b, where dots comprising photoluminescent nanoparticles with different emission wavelength ranges are used to uniquely define an indicium 190, which together with other indicium may be used to uniquely define local areas of a substrate. A first indicia wavelength range may be centered on 850nM and a second indicia wavelength range may be centered on 950nM. Indicia may comprise dots, or other shapes, positioned in any of thirty-six positions. Each possible dot position has one of four features: a dot of the first indicia wavelength range 191, a dot of the second indicia wavelength range 192, a dot with indicia wavelengths from the first and second ranges 193, or no dot. Other wavelength combinations, and other feature shapes or combinations of feature shapes may be used. For example, a four-position encoded pattern of dots may also have dots of two wavelength ranges, so each position in a 5x5 indicium has eight possible codes, resulting in more than 4^{36} unique codes in a 5x5 matrix.

Figure 2c shows an indicium 195 comprising a 5x5 array that comprise dots that fluoresce in a plurality of wavelength combinations, the wavelength combinations uniquely defining local regions of the substrate. The 25 possible positions in the array have dots having one of four features: a dot of the first indicia wavelength range 191, a dot of the second indicia wavelength range 192, a dot with indicia wavelengths from the first and second ranges 193, or no dot. The pattern is restricted to no dots at three corners, as shown; all other positions of the top, right, and bottom edges have dots that emit in at least one wavelength. This pattern provides easy recognition of indicia borders and angular orientation. Given feature-to-feature spacing of 0.3mm, a repeating pattern of unique indicia can provide pattern and

wavelength combinations uniquely defining local regions of a substrate area nearly 500,000 square meters.

Fig. 2d shows details of color filter 196 that passes two wavelength ranges of visible light and two wavelength ranges of IR light to an image detector, as could be located in a stylus, with coupled electronics that resolves a location based on signals from the image detector. Such a filter, or one like it, may be advantageously used in conjunction with resolving indicia such as indicium 190 and 195. In other embodiments, a different filter, or no filter, may be needed. The exemplary four color filter cells in filter 196 comprise cells 112 and 113 that pass IR light centered on 850nM and 950nM respectively. And visible light cells 114 and 115 that pass light centered on wavelengths 500nM and 600nM respectively. IR cells 112 and 113 preferably pass light with a bandwidth of +/- 50nM. Visible cells 114 and 115 preferably pass light with a bandwidth of +/- 100nM. Other color filter layouts may be used. In some embodiments, it may be sufficient to detect monochrome visible images, so filters 114 and 115 may both detect visible light from 450nM to 700nM, for example. In some embodiments, visible image detection may not be required.

Indicia and sensing techniques based on various patterns are further described in United States Patent Nos. 5,051,763; 5,442,147; 5,477,012; 5,852,434; 6,502,756; 6,548,768; 6,570,104; 6,586,688; 6,663,008; 6,666,376; 6,667,695; 6,689,966; 6,722,574; and 7,622,182, each of which is hereby incorporated by reference in its entirety. Anoto is just one company that has developed location unique indicia-based digitizer systems; other systems will be known by the skilled artisan, and inventions described herein may be applicable to many of them.

For digitizers that operate overlaid upon a display, indicia that produce indicia emitted light outside the visible range may be preferable. Indicia for such applications are preferably formed of any suitable material that provides emitted photoluminescence at wavelengths between 700 and 1000 nm. Such materials are readily available, as are IR filters and optical sensors that operate in this range. For example, Hamamatsu Pthotonics of Hamamatsu City, Japan, sells several charge-coupled device (CCD) optical sensors sensitive to IR wavelength ranges. For some applications, other wavelength ranges, such as longer IR wavelength ranges, may be preferable.

Any suitable photoluminescent material may be used for indicia. In one embodiment, a suitable indicia material comprises photoluminescent inks. Some example photoluminescent inks and dyes are available from QCR Solutions Corp, of Port St Lucie Florida (see dyes including IRF820A and IRF940A).
In another embodiment, photoluminescent quantum dots may be embedded in a carrier material, such as a resin or liquid, to make a dye. Quantum dots, in some embodiments, fluoresce when exposed to

stimulating light provided over a wider range of wavelengths from UV to IR, which is not true for many other fluorescent materials. Thus, quantum dots may be particularly suited for, for example, system 102 (Figure 1c and Figure 4d) where a quantum dot fluorescent material can absorb energy from a white LCD backlight. Other fluorescent materials may require a special backlight for system 102 that emits light in their specific absorption range.

There exists a wide variety of commercially available quantum dot options. Quantum dots can be selected as to provide indicia emitted light with a variety of wavelengths from the ultraviolet (for example, quantum dots comprised of ZnSe) through the visible (for example, quantum dots comprised of CdSe), and into the mid IR (>2500 nm) (for example, comprised of PbSe. Quantum dots that provide indicia emitted light in the IR range may also be made of PbS, PbSe, or InAs. Quantum dots made of PbS having diameters from about 2.7 to 4 nm will provide indicia emitted light in the near IR range of wavelengths. Quantum dots with a core of InAs and a shell of higher band gap material, for example ZnSe or PbSe with an inorganic passivation shell of CdSe, may have improved photoluminescence quantum efficiencies. Quantum dots having core of CdTeSe with a ZnS shell are commercially available from Nano Optical Materials of Torrance, California. Quantum dots stabilized with a combination of thioglycerol and dithioglycerol have also been shown to improve stability of luminescence wavelength over time. Quantum dots may be purchased commercially from companies including Nano Optical Materials, NOM's parent company Intelligent Optical Systems (also of Torrance, California), and Evident Technologies of Troy, New York. Evident Technology markets a PbS based dye with the name "Snake Eye Red 900" that may be formulated into an ink for printing. Life Technologies, of Grand Island, New York, and Nanosys, of Palo Alto, California offer printable quantum dot solutions, for example anti-counterfeit inks containing quantum dots.

Indicia may be printed onto any suitable substrate, as mentioned above. Many known printing processes may be used, including flexographic, gravure, ink jet, or micro-contact printing. Photoluminescent material may be dispersed homogeneously into an optically clear resin and deposited on a substrate using methods such as flexographic or gravure printing. Gravure printing may be preferable for printing larger photoluminescent particles such as IRF820A. Flexographic printing may have cost advantages in high volume applications. Inkjet printing may be preferred where smaller volumes of customized patterns of indicia are desired. Inkjet printing of quantum dots is described in the articles: Small, A. C., Johnston, J. H. and Clark, N., *Inkjet Printing of Water "Soluble" Doped ZnS Quantum Dots*, European Journal of Inorganic Chemistry, 2010: pp. 242–247.

Printing of indicia in a thin layer is generally preferable in embodiments where indicia are printed on a substrate that overlays a display, because refraction of light through the indicia can be minimized.

Transparency can also be maximized by thinner layers and in some cases fluorescence quenching can be reduced. Photoluminescent QD's can be printed in a monolayer using micro-contact printing. A monolayer of QD maximizes transparency to visible and IR wavelengths. In doing so, visible light transmission is maximized along with reflection of indicia-generated IR light (5a, 6a in Figure 4b, 4d).

Monolayers of quantum dots may be printed using micro-contact printing methods described in the article *Direct Patterning of CdSe Quantum Dots into Sub-100 nm Structures* (Small, A. C., et. al., European Journal of Inorganic Chemistry (2010): pp. 242–247), and the article *Fabrication and Luminescence of Designer Surface Patterns with β-Cyclodextrin Functionalized Quantum Dots via Multivalent Supramolecular Coupling* (Dorokhin, et. al., Institute of Materials Research and Engineering, Agency for Science, Technology and Research, ACS Nano (2010), 4 (1), pp. 137–142. The latter of these articles describes two methods of microcontact printing luminescent CdSe / ZnS core-shell quantum dots. In both methods, quantum dots are functionalized by coating with surface ligands of β–cyclodextrin that promote binding, and stabilize the quantum dots in a water-based colloidal suspensions. In both methods, polydimethylsiloxane (PDMS) stamps are used for micro-contact printing onto glass substrates. In one method, a substrate is first microcontact-printed with a pattern of adamantyl terminated dendrimeric material, then a colloidal suspension of functionalized quantum dots are exposed to the printed substrate, and quantum dots bind to the material printed on the substrate. In a second method, functionalized quantum dots are directly microcontact printed onto a dendrimer layer on a glass substrate.

Depending on the photoluminescent pattern required, microreplication can be used to make a tool with a negative of the desired pattern. The tool is then pressed and cured against a uniformly coated polymer layer to form consistent dents of the pattern in a polymer cured matrix. These dents can then be filled either directly with the a suitable photoluminescent material blended with a carrier or formulated into an ink using precision roll coating methods such as gravure printing, or, indirectly by using roll coating in combination with doctor-blading to remove excessive solution from areas other than within the dents.

Another way of patterning the substrate is to use a direct thermal printing process with a photoluminescent ink so that the ink resides within the well formed in the (typically polymeric) substrate by the thermal printing mechanism. This may have the added advantage of rapid single step digital processing that can provide custom patterns without, in some embodiments, the need for costly tool development.

Photoluminescent indicia can be created using either organic or inorganic dyes or pigments depending on the nature of the application. Organic dyes, such as CY7 which is available from Lumiprobe of Hallandale, Florida, provide several benefits such as high luminescence. However, the Stokes shift for

these types of dyes is typically <50 nm and the durability and light-fastness are often low, making them unsuitable for some applications. Carbon chains with conjugated bonds or aromatic rings are typical present in organic dyes, and are sometimes associated with nitrogen or sulfur atoms. For example, CY7 consists of a cyclohexane-bridged polymethyne chain.

Inorganic dyes, pigments, phosphors or other luminescent materials, such as the earlier mentioned Snake Eye Red provide another solution. The Stokes shifts for these materials can be relatively high due to the large bandwidth of the absorption curves compared to organic dyes. These materials consist of the cations of metal in an array with the non-metallic ions, such as lead-sulfide (PbS) in Snake Eye Red.

Turning now to figure 1b, a stylus digitizer system 101 is shown, comprising stylus 120, digitizer panel 115 patterned with photoluminescent indicia, display 105a, and electronic controller 130 that receives position-related information from stylus 120 and controls displayed images via link 135. Display 105a emits or reflects visible light, and display 105a is at least partially transmissive to stylus emitted stimulating light 3 and to indicia emitted light 5. Display 105A may be a transparent OLED display, or static printed image, or other display type.

Turning now to figure 1c, a stylus digitizer system 102 is shown, comprising stylus 120, digitizer panel 115 with photoluminescent indicia, LCD 107, backlight 108, and electronic controller 130 that receives position-related information from stylus 120 and controls displayed images via link 145. Stylus 120 detects patterns of light 5 emitted from indicia on digitizer panel 115. Indicia emitted light 5 preferably has a different wavelength range than visible light emitted from backlight 108. Indicia emitted light 5 preferably has a wavelength range including wavelengths sufficiently long such that they penetrate LCD 107 regardless of the On/Off state of the pixels in LCD 107. For example, 950 nm light penetrates most LCDs regardless of pixel state. Indicia on digitizer panel 115 are energized by stimulating light from backlight 108, so an indicia stimulating light source on stylus 120 is optional and not required.

Figure 1d shows stylus digitizer system 103 comprising stylus 120, digitizer panel 115 with photoluminescent indicia, and electronic controller 130. Stylus 120 irradiates indicia on digitizer panel 115 with stimulating light 3 and detects indicia emitted light 5. Digitizer panel 115 may be printed with various graphics, or it may appear blank (as for e.g. a blank sheet of paper), and may be opaque. Stylus 120 may be combined with pen functionality (not shown in Figure 1d). Digitizer pane 115 may be a whiteboard, for example as used in a classroom, and the marker may be incorporated into the stylus, or the digitizer pane may comprise a screen onto which a display is projected.

Figure 3a shows a cross sectional view of a portion of stylus 120. Stylus body 41 contains optional light source 34 that may emit stimulating light 3 having a first wavelength range. Indicia emitted light 5 having a second wavelength range enters the tip of stylus 120 and is passed through filter 43. Filter 43 selectively passes at least some portion of the second wavelength range of indicia emitted light 5 while blocking light of the first wavelength range (that was emitted by light source 34). For example indicia may emit 800nm to 1200nm light and filter 43 may pass light of wavelengths between 750nm and 1200nm while blocking light wavelengths below 750nm. Lens 48 focuses indicia emitted light 5 to pass through aperture 33 then reflect from mirror 32 onto image sensor 45. Lens 48 may be made of IR transparent, visible light blocking material so lens 48 can also perform the filtering function of filter 43.

Image sensor 45 may be any suitable sensor. Sensors based on charge-coupled devices (CCDs) and complementary metal–oxide–semiconductor (CMOS) technologies are used interchangeably in multiple areas of imaging, and may be suitable in this application. In some embodiments, light 5 may have a plurality of wavelength combinations that uniquely define local regions of a substrate. In these embodiments, image sensor 45 may further include a color filter that passes selected wavelengths of light 5 to some pixels and different wavelengths to other pixels of sensor 45.

Image sensor 45 is connected to stylus processor 44 by conductors on printed circuit board (PCB) 46. Light source 34 is connected to PCB 46 by link 36. Stylus processor 44 controls image sensor 45 and light source 34 via conductors on PCB 46 and by link 36 respectively. In addition, the stylus processor controls collection of image information from image sensor 45 and communicating this to processor 130 via link 124, (shown in Figure 1a). Stylus 120 may also comprise additional components such as switches and a battery, (not shown). Stylus 120 may also comprise a probe 51 extending from the stylus that provides spacing for the optical components, and may retract upon contact with the surface of the digitizer, causing certain stylus electronics to activate. Probe 51 may be made of solid plastic, or metal, and it may contain ink for writing on a surface with stylus 120.

The wavelength range of light source 34 must be in a range that stimulates indicia to produce luminescence at a desired wavelength and brightness. In one example, indicia emitted light (luminescence) fluoresces due to stimulation by light in another, shorter wavelength range. In some embodiments it may be preferable that the stimulating light and the indicia emitting light be minimally visible to the user. These criteria are met if light source 34 emits UV-A light, for example between 350 nm and 420 nm or if light source 34 emits near IR light, for example between 700 nm and 850 nm. Stimulating light may instead, or in addition, be generated by other components, such as backlights in an LCD panel, or other radiation sources.

Stylus 120A (Figure 3b) is similar to stylus 120, except it has an additional light source 35. This light source may be beneficially used in stylus embodiments that need to sense both photoluminescent indicia and traditional reflective indicia (the latter commercially available from Anoto). For example, in fluorescent mode, processor 44 may select light source 34 to irradiate indicia that fluoresce when exposed to radiation of a given wavelength range, and in reflecting mode, processor 44 may select source 35 to irradiate and illuminate indicia that do not fluoresce.

Referring now to Figure 4a, photoluminescent indicia 119 are deposited on the surface of visible light transmissive substrate 118. Indicia may be deposited by printing a thin layer of photoluminescent material. For example fluorescent quantum dots may be mixed with a printable medium, and printed using known methods. Indicia-printed substrate 118 is then laminated to durable overlay 116, which may be glass, acrylic, or any suitable transparent working surface that will protect the indicia. Alternatively, indicia may be printed on the bottom surface of overlay 116.

Adhesive 117 that binds substrate 118 to overlay 116 may be an optically clear adhesive (OCA) such as those sold be 3M Co. of St Paul, MN, USA. Adhesive 117 may be replaced by an air gap, (providing indicia 119 have an environmentally protective coating) and air gap 109 may also be replaced with an OCA.

Stimulating light 3 and 3a emitted by stylus 120 has a first wavelength range (for example, near UV-A or near IR). Light 3a that does not get absorbed by indicia 119 passes through substrate 118, and is absorbed or reflected by layers below. Some of light 3 is absorbed by indicia 119 which causes indicia 119 to emit indicia emitted light 5 in various directions, including into the stylus housing which includes optical sensing electronics, as described earlier. Indicia emitted light 5, in this embodiment, is primarily in a second wavelength range, in this case it is within the IR range. Visible display light 7 and 8 is emitted from display 105. Some display light 8 that hits indicia 119 will pass through the indicia. Some of the display light 2 may also be absorbed by the indicia 119 and will cause fluorescence resulting in light 6. Ambient light 9 may also cause photoluminescence in indicia 119, resulting in indicia emitted light 6.

Display 105 is shown as a planar cross section, but display 5 may include other shapes. For example, the display may comprise a rear projector and a rear projection panel.

Figure 4b shows a digitizer system identical to that in Figure 4a, except substrate 118 is replaced by dichroic substrate 148 that passes light of some the first wavelength range while reflecting light of the second wavelength range, where wavelengths of the first range are typically shorter than wavelengths of the second. For example, substrate 148 may be visibly transparent IR reflective material such as 3M

Company's multilayer optical films (MOF) which are available commercially under the names Crystalline automotive films and Prestige Series residential window films. Dichroic reflective substrate 148 increases the efficiency of the system by re-directing indicia-generated light of the second wavelength range that would not otherwise have reached stylus 120. 3M's PR90EX film may be used for the reflective substrate 148.

Figure 4c shows a magnified cross section view of a portion of digitizer and display system 102 (see Figure 1c). In this embodiment, indicia stimulating light is provided by backlight 108. In other embodiments, however, the stylus could additionally include such a further radiation source.

If display 107 is a light emitting display such as a (transparent) OLED, backlight 108 may not be required. Where optional backlight 108 is used (for example, in combination with an LCD display), visible (white) display light 7 and 8 may be emitted from optional display backlight 108. A portion of light 7 that is not absorbed by Indicia 119A passes through substrate 118, optically clear adhesive layer 117, and through pixels of display 107, to form a displayed image. Light from backlight 108, may comprise wavelengths outside the visible spectrum. For example, near infrared (IR) light (700 nm – 1000 nm) or near UV light (e.g. 350 nm – 400 nm) may be emitted from the backlight to energize indicia on substrate 118. Some of these wavelengths may be filtered out by layers above the indicia, (for example, the color filter of display 107, which would be typical if 107 were an LCD), so minimal amounts of these wavelengths of light may reach the user. An LCD display comprising quantum dots energized by a backlight is described in US Patent Application No. 2008/0246388, "Infrared Display with Luminescent Quantum Dots."

Figure 4d shows a magnified cross section view of a portion of digitizer and display system 103 (see Figure 1d). The stylus, in this embodiment, is similar to that described with respect to Figure 4b, in that it includes a radiation source that excites the indicia. This embodiment shows the use of photoluminescent position-unique indicia in a whiteboard-type environment. A transparent overlay including photoluminescent indicia 119 and optically clear adhesive layer 117, as well as substrate 156 (here, substantially light transmissive such that graphics on the surface of substrate 158 are visible through the stack comprising substrate 156 and OCA 117). Surface 159 of substrate 156 may be layered with a material, such as Tedlar® (available from DuPont), polypropylene, or other surface compatible with white-board applications, or it could be an anti-scratch, anti-reflective, anti-glare, polarizing, or color filtering layer. Substrate 156 may comprise a plurality of layers. In such embodiment, stylus 120 may include inks compatible with whiteboard applications, such that a user may write on the whiteboard while electronics in the stylus computes coordinates of the writing and provides these to a computer.

Figure 4e shows the use of photoluminescent indicia in a paper-type environment. Photoluminescent indicia 119 are deposited on the top surface of substrate 168, which may be paper, cardboard, PET, PEN, glass, acrylic, or any material that supports indicia 119. Indicia 119 are deposited by printing a thin layer of photoluminescent material. For example fluorescent quantum dots (QD's) may be mixed with a printable medium, and printed using known methods. Indicia-printed substrate 168 may then be covered with optional layer 167 that is transparent to stylus emitted stimulating light 3 and indicia emitted light 5. Layer 167 may optionally be added to protect indicia. Layer 167 may be an anti-scratch layer, a durable layer comprising a polymer hardcoat, or a polymer hardcoat filled with silica particles, or a sheet of material such as PET may be laminated to substrate 168. Surface 169 may have anti-reflective (AR), and/or anti-glare (AG) properties. Additionally, substrate 168 may be printed with a visible static image. While the pen showed in Figure 4e includes a radiation source to excite indicia within the stylus FOV, depending on the application, the stylus could sense indicia excited by other means, such as ambient light 9. In such case, the stylus would not necessarily need a radiation source.

Figure 4f shows a somewhat different embodiment, where stylus 121 senses indicia in reflecting mode. In this embodiment, stylus 121 provides a radiation source (similar to light source 34 in Figure 3a) that is reflected by substrate 178, but not reflected by, or minimally reflected by, indicia 179. Indicia 179 preferably comprise a thin layer of IR-absorbing photoluminescent material; substrate 178 is preferably an IR-reflecting material; and the sensor component in stylus 121 senses the reflected IR, but not the indicia-emitted light. Thus this embodiment provides a "negative" image of the indicia, which may be desirable in some embodiments.

The embodiment shown in Figure 4f could be modified to use stylus 121A, which provides a radiation source (light source 35 in Figure 3a) that is reflected by substrate 178, but not reflected by indicia 179. Indicia 179, in this embodiment, would preferably comprise a thin layer of IR-absorbing material; light source 35 would provide light in the IR bandwidth; substrate 178 would preferably an IR-reflecting material; and the sensor component in stylus 121 senses the reflected IR. Such an embodiment could enable the stylus to have, in effect, two modes of operation depending on the indicia and the two radiation sources: a first mode that senses the luminescence of the indicia; and a second mode that senses reflected light from the substrate, but not from the indicia (or vice versa).

The digitizer panel can be integrated into a display stack-up in a variety of ways using a variety of rigid or flexible materials. One embodiment shown in Figure 5a comprises an overlay where the digitizer panel is attached to a device 205, in an after-market application using self-wetting adhesive 201. This panel is constructed by forming the photoluminescent indicia 202, on one side of substrate 200 (in this case PET), and covering these indicia with said adhesive 201. To attach the panel, the user would place the

adhesive-side of the panel onto the device 205. To improve the durability of the overlay, a hard-coat may be added to the side of the panel that faces the user.

Another embodiment shown in Figure 5b for an overlay in aftermarket applications would be constructed by first printing the indicia 202 on multilayer optical film (MOF) 203, which reflects IR. In this construction, the device-facing adhesive 204 would be placed on the opposite side as the indicia since the emitted signals from the photoluminescent dyes would not pass through MOF 203. To further protect the indicia from the user's interaction, a protective layer 200, such as PET, may be adhered to the top of the MOF to cover the indicia, using adhesive 201.

Another embodiment is an underlay where the digitizer panel is attached to a touch-sensitive screen including but not limited to those product offerings from 3M Touch Systems, as a surface-capacitive technology (SCT) screen or a projected-capacitive technology (PCT) screen. Figure 5c shows such an embodiment, where the photoluminescent indicia 202, formed on a transparent substrate 200, such as PET or MOF, covered with an optically-clear adhesive, 201. This adhesive would then be attached to the back of the touch sensitive screen 205, using a variety of methods known in the art. Another embodiment as shown in Figure 5d is to print the photoluminescent indicia 202 directly onto the touch sensitive screen 205, either at the beginning, middle, or end of an already established process.

Another embodiment shown in Figure 5e is specific to a layered touch sensor, such as a PCT screen, as an underlay solution. In such an embodiment, the photoluminescent indicia 202 are disposed on the same layer 206 as the component or components including the matrix of electrodes, and then the screen may be integrated to as normal into other devices.

Yet another option is shown in Figure 5f, which shows the digitizer panel as an underlay between the cover lens of a touch sensitive screen 205 (in this case a visible light transmissive PCT screen) and the layer 206 that includes the matrix of electrodes, by forming photoluminescent indicia 202 on a visible-light-transparent substrate 200, which could comprise materials such as PET or MOF, and adhering this to the cover glass using a variety of methods known to the art. The resultant stack can then be adhered to the digitizer panel using methods known in the art (for example, by laminating with optically clear adhesive 201).

Example

This example describes the set-up that may be used to demonstrate fluorescent indicia that can be viewed at various stylus angles. It consists of a radiation source, a fluorescent medium, and an image sensor placed behind a suitable filter. The radiation source comprised a light emitting diode (UVXTZ-400-15

supplied by BIVAR, Inc, of Irving, California), powered with 20 mA of current and placed at a distance of about 3 cm from the substrate on which a fluorescent dye was printed to form position-unique photoluminescent indicia. The diode had a spectral emission centered at about 400 nm. Light from the diode was incident on the printed fluorescent dye IRF820A and caused photoluminescent emission. The photoluminescent material comprised IRF820A, which was purchased from QCR Solutions Corp. of Port Saint Lucie, Florida. It came in a powder form with a quantum efficiency quoted at 0.2 for fluorescence between 700 nm and 1000 nm.

As an initial experiment, the fluorescent particles were dispersed at room temperature into OP2001 Matte Varnish resin at a concentration of 0.5% and manually deposited onto a small sample of MOF using a toothpick. The OP2001 Matte Varnish was purchased from the series for UV Flexo Varnishes of Nazdar Company of Shawnee, Kansas. The MOF substrate comprised PR90EX manufactured by 3M Corporation of St. Paul, Minnesota. This particular MOF was high in transmission over the visible range and was highly reflective beyond 850 nm. An optical filter was placed in the path of the light entering a CCD image sensor that was used as an imaging tool in the stylus. The optical filter was a long pass filter, comprising Clarex NIR-75N, supplied by Astra Products of Baldwin, New York. This filter suppressed transmission of light wavelengths below 750 nm. As a result, specular reflection from the diode that obscured some indicia in was largely suppressed from reaching the image sensor, while IR light emitted by the fluorescent dye was detected by the image sensor, resulting in a clear image of position-unique photoluminescent indicia on the substrate.

In a further experiment, a radiation source comprised a light emitting diode (L750-04AU supplied by Marubeni America Corporation of Santa Clara California), powered with 20 mA of current and placed at a distance of about 3 cm from the substrate onto which a fluorescent dye was printed to form position-unique photoluminescent indicia. The diode had a spectral emission centered at about 750 nm. Light from the diode was incident on the printed fluorescent dye EviDot Snake Eyes and caused photoluminescent emission. The photoluminescent material comprised EviDot Snake Eyes, which was purchased from Evident Technologies of Troy New York. It came in a liquid form of quantum dots in toluene with a quantum efficiency quoted at 0.3 for fluorescence between 400 nm and 1000 nm. As an initial experiment, the fluorescent particles were dispersed at room temperature into Integrity 1100D and manually deposited onto a small sample of PET using screen-printing techniques. The Integrity 1100D was purchased from Hexion Specialty Chemicals of Columbus Ohio by Evident Technologies. The PET substrate comprised ST505 manufactured by Dupont Teijin Films of Chester Virginia. This particular PET is a clear, heat stabilized polyester film which is pre-treated on both sides for improved adhesion. An optical filter was placed in the path of the light entering a CCD image sensor that was used as an imaging tool in the stylus. The optical filter was a long pass filter, comprising Clarex NIR-85N, supplied

by Astra Products of Baldwin, New York. This filter suppressed transmission of light wavelengths below 850 nm. As a result, specular reflection from the diode that obscured some indicia in was largely suppressed from reaching the image sensor, while IR light emitted by the fluorescent dye was detected by the image sensor, resulting in a clear image of position-unique photoluminescent indicia on the substrate. These results were achieved at various stylus angles.

Unless otherwise indicated, all numbers expressing quantities, measurement of properties, and so forth used in the specification and claims are to be understood as being modified by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and claims are approximations that can vary depending on the desired properties sought to be obtained by those skilled in the art utilizing the teachings of the present application. Not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, to the extent any numerical values are set forth in specific examples described herein, they are reported as precisely as reasonably possible. Any numerical value, however, may well contain errors associated with testing or measurement limitations.

The following are items of the present disclosure:

Item 1 is a digitizer system comprising:

a substrate with position-unique photoluminescent indicia comprising a pattern of features that emit a plurality of wavelength combinations, the wavelength combinations uniquely defining local regions of the substrate;

a stylus comprising an optical image sensor configured to sense the photoluminescent indicia;

a processor configured to receive signals from the optical image sensor and provide location-specific positional signals based on the received signals.

Item 2 is the digitizer system of item 1, wherein the wavelength combinations uniquely define local regions of the substrate.

Item 3 is the digitizer system of item 1, wherein the combination of pattern features and the wavelength combinations uniquely define local regions of the substrate.

Item 4 is the digitizer system of item 1, wherein the pattern of features is a repeating pattern .

Item 5 is the digitizer system of item 1, wherein the features comprise dots.

Item 6 is the digitizer system of item 1, wherein the photoluminescent indicia are visible light transmissive.

Item 7 is the digitizer system of item 6, wherein the substrate is visible light transmissive.

Item 8 is the digitizer system of item 6, further comprising:

a display with electronically addressable pixels.

Item 9 is the digitizer system of item 8, wherein the electronically addressable display is a liquid crystal display, a plasma display, an OLED display, or a projection display.

Item 10 is the digitizer system of item 8, wherein the electronically addressable display is registered to the substrate.

Item 11 is the digitizer system of item 10, wherein the substrate is disposed above the electronically addressable display, such that light from the display is transmitted through the substrate.

Item 12 is the digitizer system of item 10, wherein the substrate is disposed behind the electronically addressable pixels of the display.

Item 13 is the digitizer system of item 1, wherein the optical image sensor has a field-of-view, and the optical image sensor senses photoluminescent indicia passing within the field-of-view.

Item 14 is the digitizer system of item 1, wherein features of the photoluminescent indicia photoluminesce upon exposure to radiation within a first wavelength range, and further comprising:

a radiation source that provides radiation that includes at least one wavelength within the first wavelength range.

Item 15 is the digitizer system of item 14, where the radiation source is disposed within the stylus to provide radiation to an area corresponding to at least a portion of the optical image sensor's field-of-view.

Item 16 is the digitizer system of item 14, wherein the radiation source is within a display with electronically addressable pixels.

Item 17 is the digitizer system of item 16, wherein the electronically addressable display includes a backlight, and wherein the radiation source is the backlight.

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Item 18 is the digitizer system of item 1, wherein at least some features of the photoluminescent indicia photoluminesce providing radiation within a first indicia wavelength range.

Item 19 is the digitizer system of item 18, wherein at least some features of the photoluminescent indicia photoluminesce providing radiation within a second indicia wavelength range.

Item 20 is the digitizer system of item 18, wherein the first indicia wavelength range overlaps the second indicia wavelength range.

Item 21 is the digitizer system of item 18, wherein the first indicia wavelength range does not overlap with the second indicia wavelength range.

Item 22 is the digitizer system of item 18, wherein the first wavelength range does not overlap the second wavelength range.

Item 23 is the digitizer system of item 19, wherein the second indicia wavelength range includes wavelengths longer than those included in the first wavelength range.

Item 24 is the digitizer system of item 19, wherein the second wavelength range includes wavelengths shorter than those included in the first wavelength range.

Item 25 is the digitizer system of item 1, wherein the photoluminescent indicia fluoresce.

Item 26 is the digitizer system of item 18, wherein the first indicia wavelength range consists of wavelengths between about 700 nm and about 2000 nm.

Item 27 is the digitizer system of item 18, wherein the optical image sensor is sensitive to radiation within the first and second indicia wavelength ranges.

Item 28 is the digitizer system of item 1, wherein the substrate comprises one of the following: polyethylene terephthalage, polyethylene naphthalate, cellulose triacetate, or glass.

Item 29 is the digitizer system of item 1, wherein features of the photoluminescent indicia are comprised of photoluminescent material.

Item 30 is the digitizer system of item 29, wherein the photoluminescent material comprises quantum dots.

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Item 31 is the digitizer system of item 29, wherein the photoluminescent material comprises inorganic nanoparticles.

Item 32 is the digitizer system of item 29, wherein the photoluminescent material is organic.

Item 33 is the digitizer system of item 8, further comprising a computer communicatively coupled to the processor and the electronically addressable pixels of the display, and wherein the computer receives location-specific positional signals and then provides signals to the electronically addressable pixels of the display that cause the electronically addressable pixels to modify their states based on the location-specific positional signals.

Item 34 is the digitizer system of item 19, wherein the stylus additionally comprises one or more filters to separate at least some portion of radiation in the first indicia wavelength range from radiation in the second indicia wavelength range.

Item 35 is the digitizer system of item 34, wherein the filter passes radiation of the first indicia wavelength range to pixels of the stylus optical image sensor, and passes radiation of the second indicia wavelength range to different pixels of the optical image sensor.

Item 36 is the digitizer system of item 1, wherein the stylus additionally comprises a filter to selectively prevent certain wavelengths of radiation from stimulating certain pixels of the optical image sensor.

Item 37 is the digitizer system of item 34, wherein the filter is transmissive to radiation in a range of wavelengths associated with the photoluminescent properties of the indicia.

Item 38 is the digitizer system of item 36, wherein the filter comprises a signal processing algorithm.

Item 39 is a substrate having position-unique photoluminescent indicia, the indicia comprising a pattern of features that fluoresce in a plurality of wavelength combinations, the wavelength combinations uniquely defining local regions of the substrate.

Item 40 is the digitizer system of item 39, wherein the combination of pattern features and the wavelength combinations uniquely define local regions of the substrate.

Item 41 is the digitizer system of item 39, wherein the pattern comprises spaced apart features, and wherein the spacing of the features forms a pattern that repeats across local regions of the substrate.

Item 42 is the digitizer system of item 39, wherein the features comprise dots.

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Item 43 is the digitizer system of item 39, wherein the photoluminescent indicia are visible light transmissive.

Item 44 is the digitizer system of item 43, wherein the substrate is visible light transmissive.

Item 45 is the digitizer system of item 39, wherein features of the photoluminescent indicia photoluminesce upon exposure to radiation within a first wavelength range.

Item 46 is the digitizer system of item 39, wherein at least some features of the photoluminescent indicia photoluminesce providing radiation within a first indicia wavelength range.

Item 47 is the digitizer system of item 46, wherein at least some features of the photoluminescent indicia photoluminesce providing radiation within a second indicia wavelength range.

Item 48 is the digitizer system of item 47, wherein the first indicia wavelength range overlaps the second indicia wavelength range.

Item 49 is the digitizer system of item 47, wherein the first indicia wavelength range does not overlap with the second indicia wavelength range.

Item 50 is the digitizer system of item 47, wherein the first wavelength range does not overlap the second wavelength range.

Item 51 is the digitizer system of item 47, wherein the second indicia wavelength range includes wavelengths longer than those included in the first wavelength range.

Item 52 is the digitizer system of item 47, wherein the second wavelength range includes wavelengths shorter than those included in the first wavelength range.

Item 53 is the digitizer system of item 39, wherein the features of the photoluminescent indicia fluoresce.

Item 54 is the digitizer system of item 47, wherein the first indicia wavelength range consists of wavelengths between about 700 nm and about 2000 nm.

Item 55 is the digitizer system of item 39, wherein the substrate comprises one of the following: polyethylene terephthalate, polyethylene naphthalate, cellulose triacetate, or glass.

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Item 56 is the digitizer system of item 39, wherein features of the photoluminescent indicia are comprised of photoluminescent material.

Item 57 is the digitizer system of item 56, wherein the photoluminescent material comprises quantum dots.

Item 58 is the digitizer system of item 56, wherein the photoluminescent material comprises inorganic nanoparticles.

Item 59 is the digitizer system of item 56, wherein the photoluminescent material is organic.

Various modifications and alterations of this invention will be apparent to those skilled in the art without departing from the spirit and scope of this invention, and it should be understood that this invention is not limited to the illustrative embodiments set forth herein. For example, the reader should assume that features of one disclosed embodiment can also be applied to all other disclosed embodiments unless otherwise indicated. It should also be understood that all U.S. patents, patent application publications, and other patent and non-patent documents referred to herein are incorporated by reference, to the extent they do not contradict the foregoing disclosure.

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Claims:

1. A digitizer system comprising:

a substrate with position-unique photoluminescent indicia comprising a pattern of features that emit a plurality of wavelength combinations, the wavelength combinations uniquely defining local regions of the substrate;

a stylus comprising an optical image sensor configured to sense the photoluminescent indicia;

a processor configured to receive signals from the optical image sensor and provide location-specific positional signals based on the received signals.

2. The digitizer system of claim 1, wherein the wavelength combinations uniquely define local regions of the substrate.

3. The digitizer system of claim 1, wherein the combination of pattern features and the wavelength combinations uniquely define local regions of the substrate.

4. The digitizer system of claim 1, wherein the photoluminescent indicia are visible light transmissive.

5. The digitizer system of claim 1, further comprising:

a display with electronically addressable pixels.

6. The digitizer system of claim 1, wherein features of the photoluminescent indicia photoluminesce upon exposure to radiation within a first wavelength range, and further comprising:

a radiation source that provides radiation that includes at least one wavelength within the first wavelength range.

7. The digitizer system of claim 5, further comprising a computer communicatively coupled to the processor and the electronically addressable pixels of the display, and wherein the computer receives location-specific positional signals and then provides signals to the electronically addressable pixels of the display that cause the electronically addressable pixels to modify their states based on the location-specific positional signals.

8. A substrate having position-unique photoluminescent indicia, the indicia comprising a pattern of features that fluoresce in a plurality of wavelength combinations, the wavelength combinations uniquely defining local regions of the substrate.

9. The digitizer system of claim 8, wherein the photoluminescent indicia are visible light transmissive.

10. The digitizer system of claim 8, wherein the features of the photoluminescent indicia fluoresce.

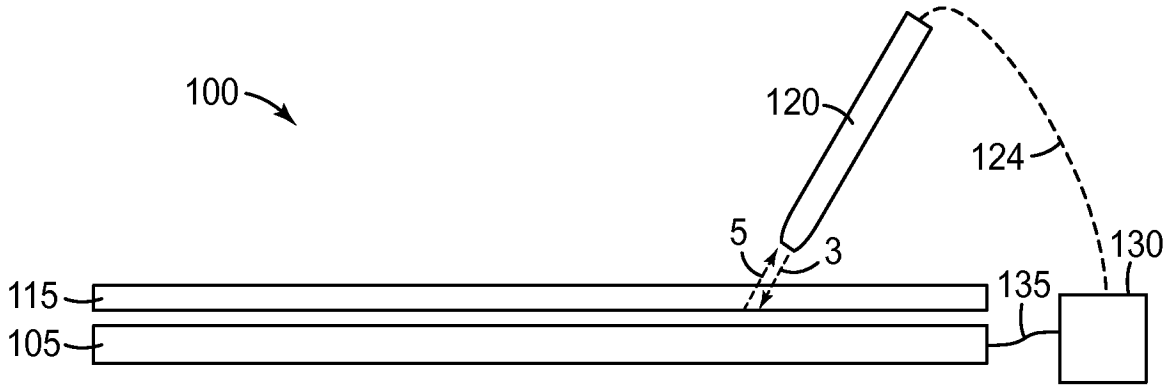


FIG. 1A

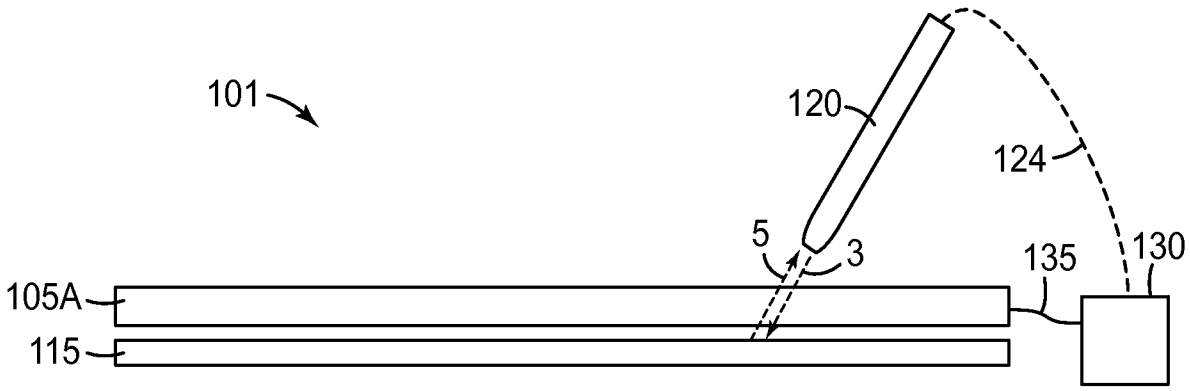


FIG. 1B

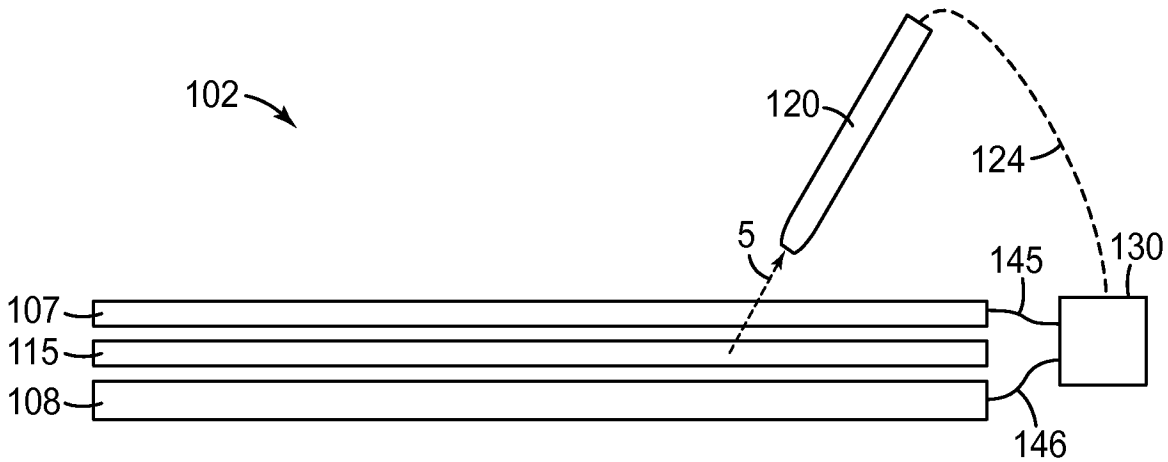


FIG. 1C

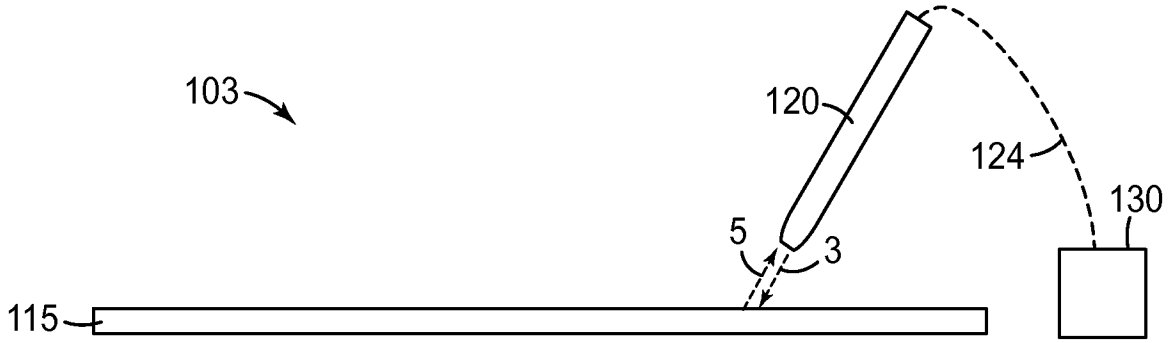


FIG. 1D

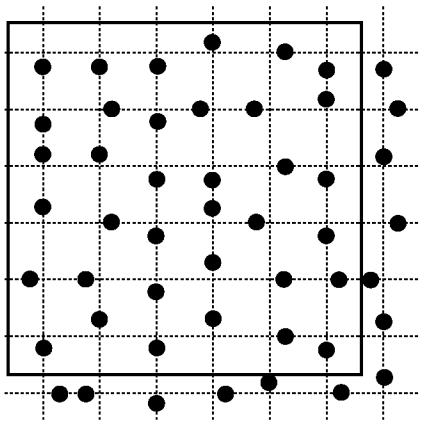


FIG. 2a
Prior Art

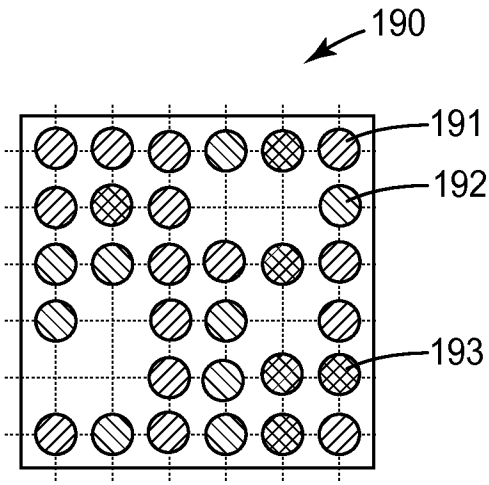


FIG. 2b

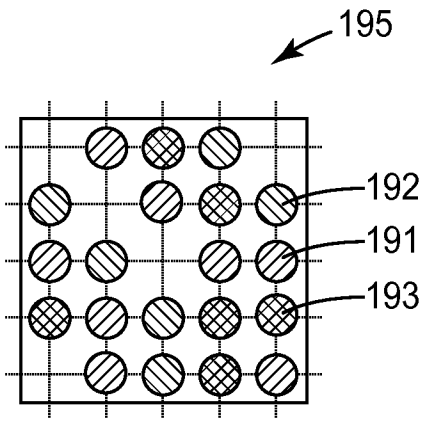


FIG. 2c

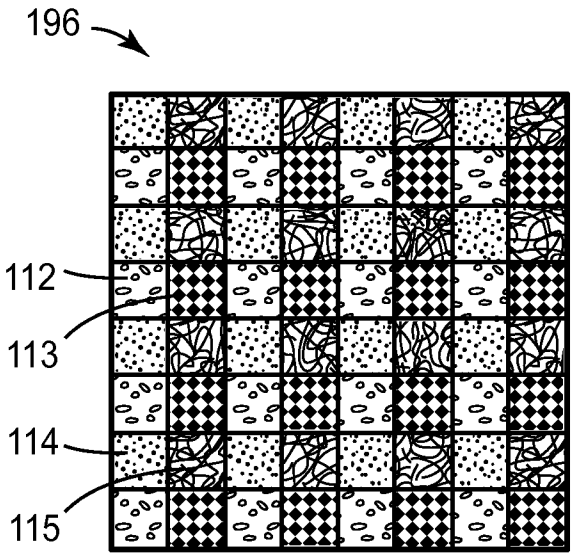


FIG. 2d

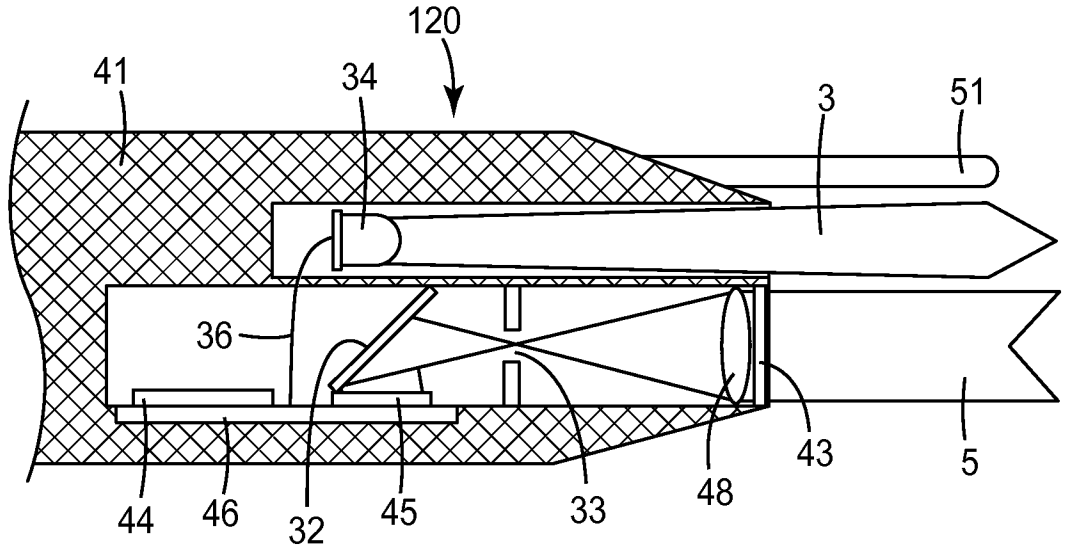
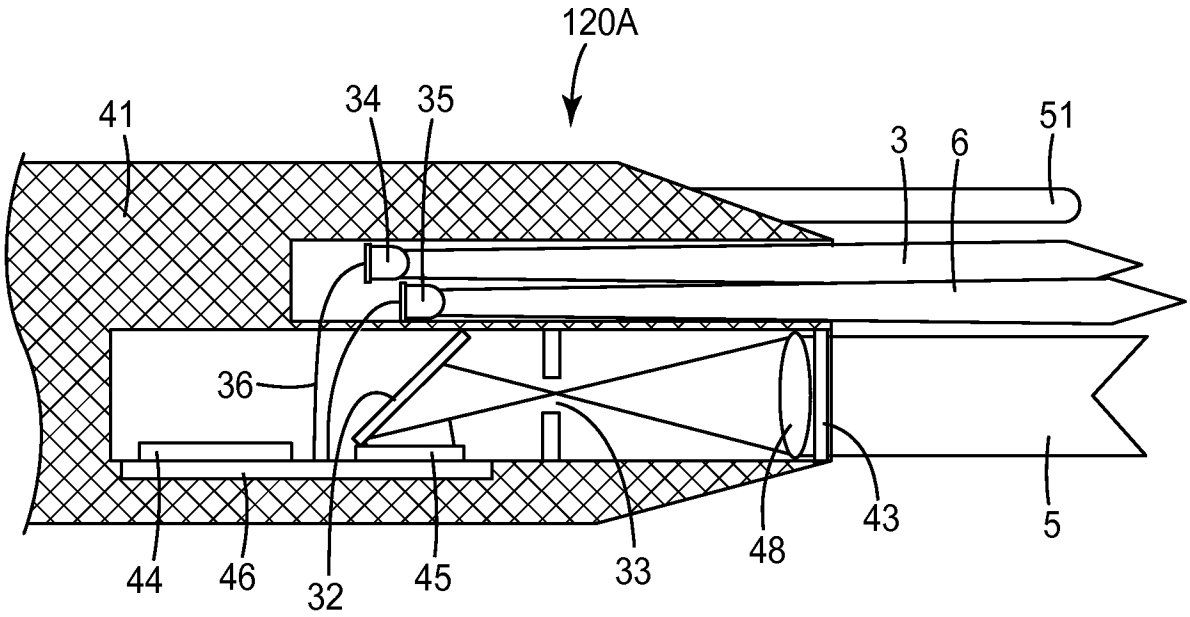

120
41
34
3
51
36
43
5
44
46
32
45
33
48

FIG. 3A


120A
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34
35
3
6
51
36
43
5
44
46
32
45
33
48

FIG. 3B

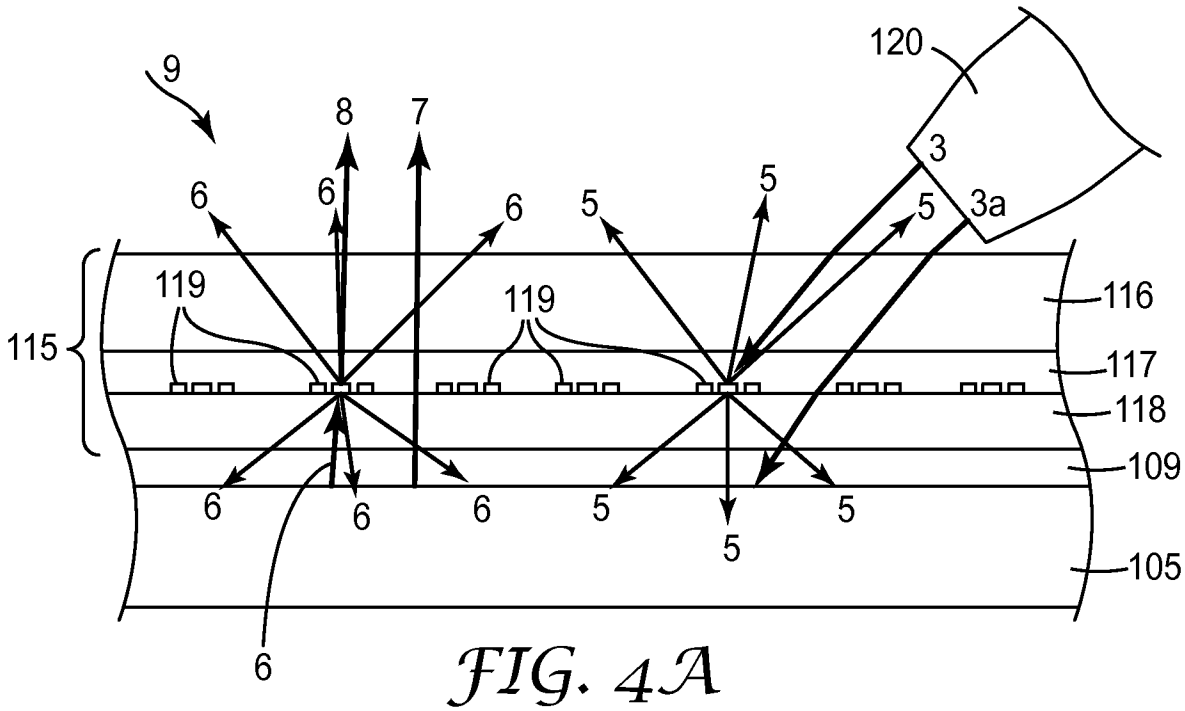
9
8
7
120
3
6
6
6
5
5
5
3a
119
119
115
116
117
118
109
6
6
6
5
5
5
105
6

FIG. 4A

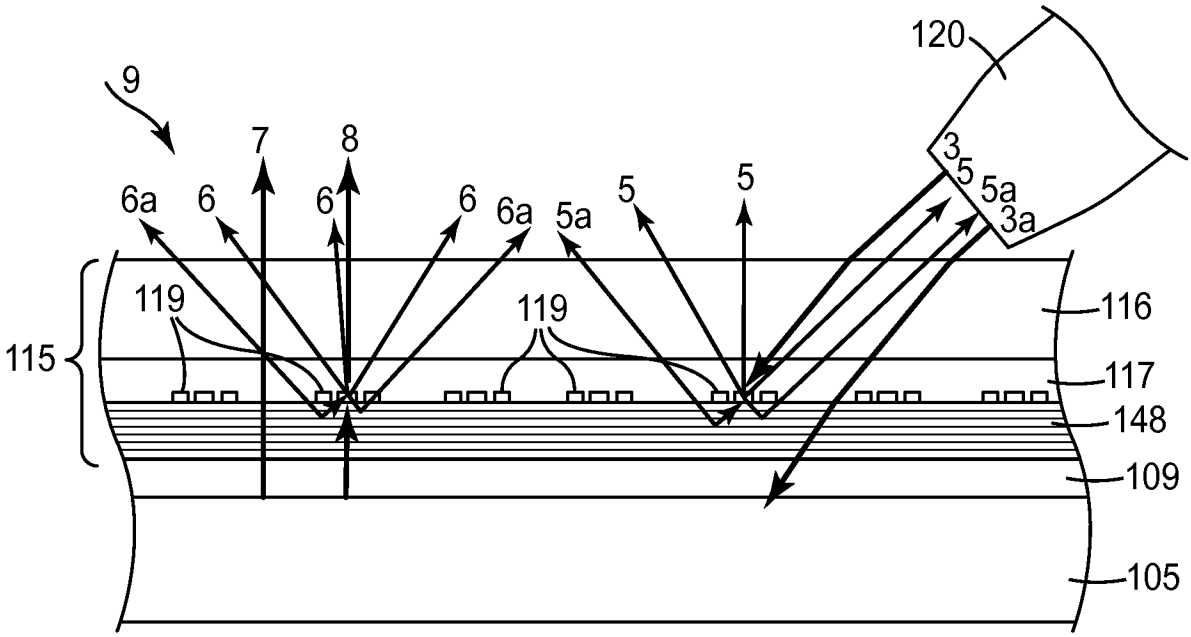
120
9
7
8
3
5
5a
6a
6
6
6
6a
5a
5
5
3a
119
119
115
116
117
148
109
105

FIG. 4B

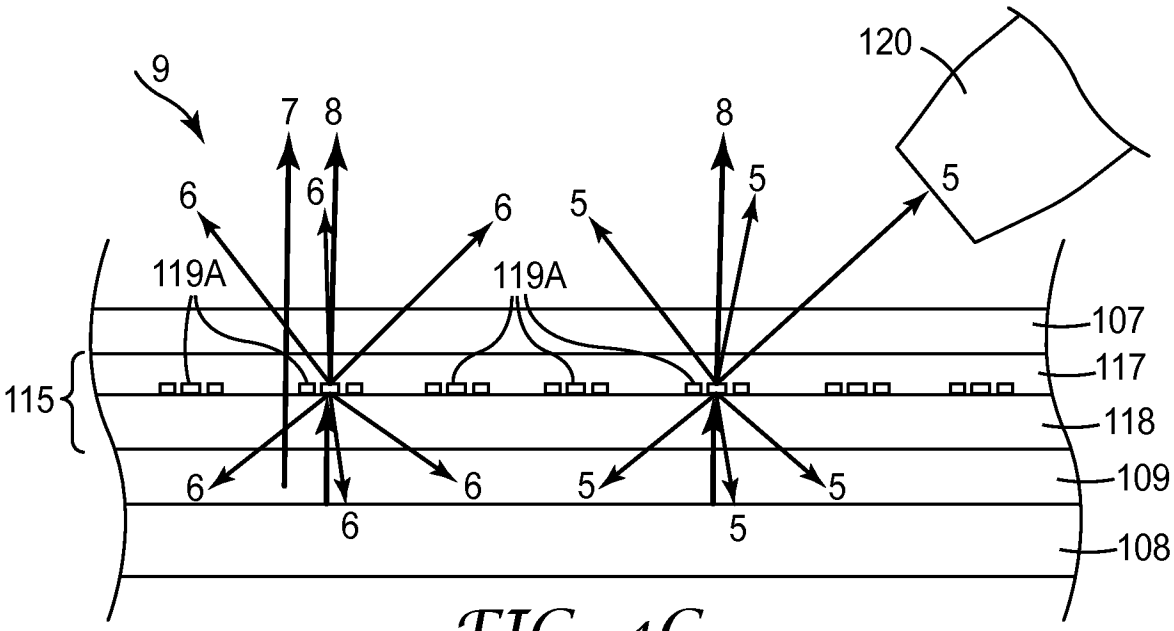
9
7
8
6
6
6
119A
119A
8
5
5
120
5
107
117
118
109
108
115
6
6
6
5
5
5

FIG. 4C

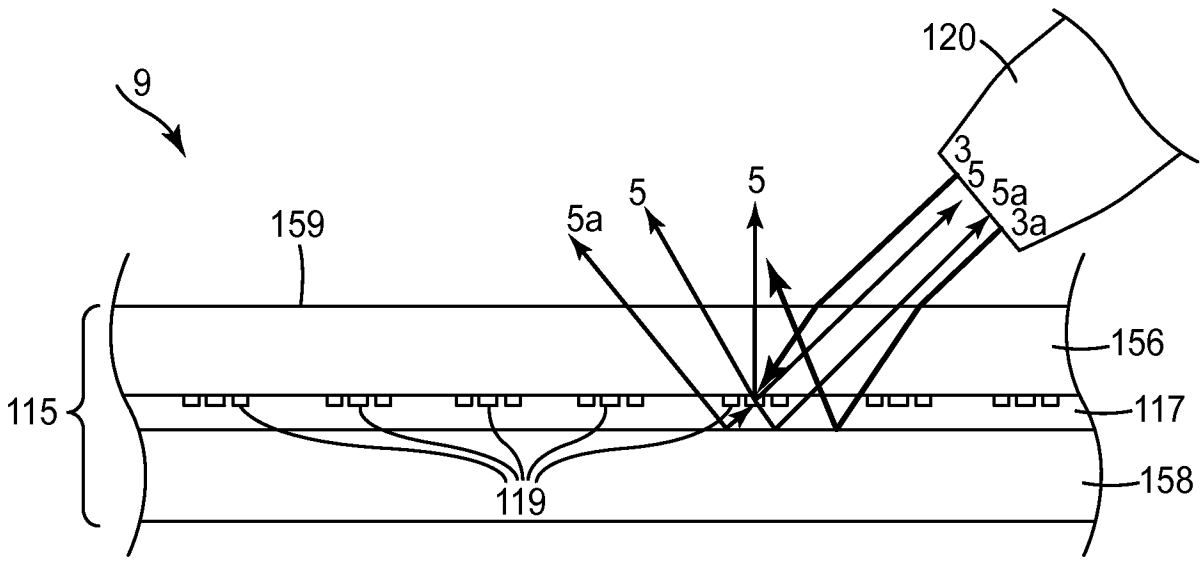
9
120
3
5
5a
3a
5
5
5a
159
156
117
158
115
119

FIG. 4D

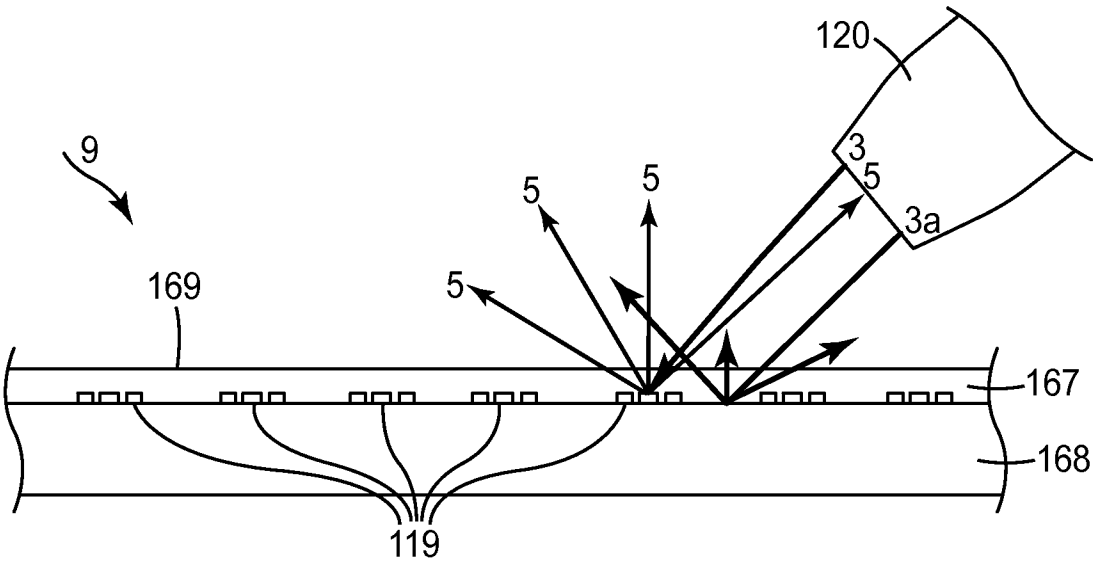

FIG. 4E

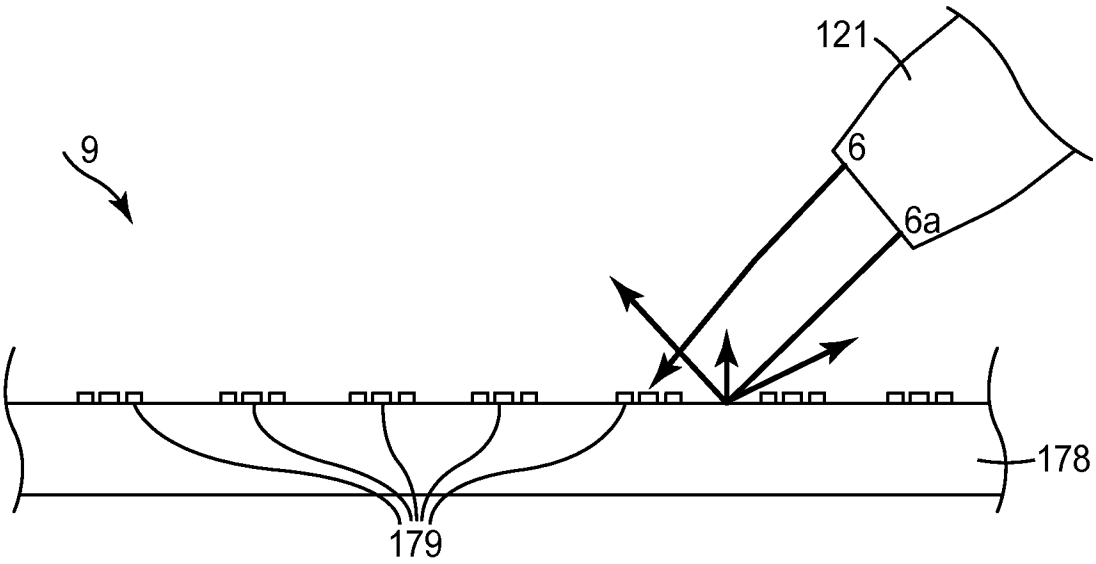

FIG. 4F

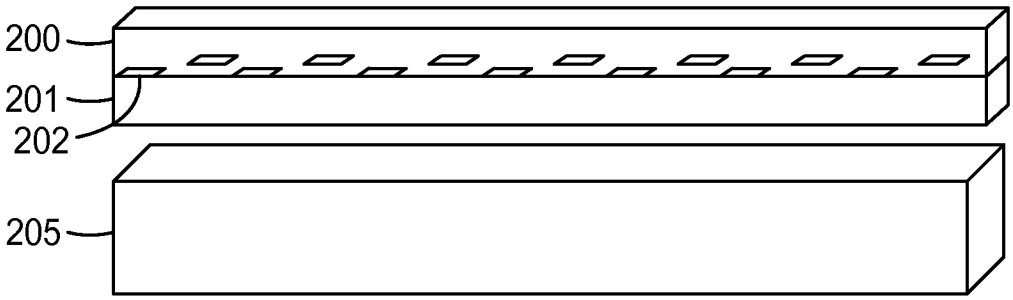

FIG. 5A

FIG. 5B

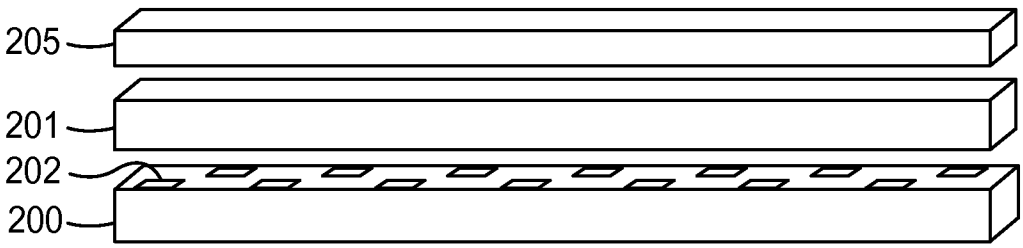

FIG. 5C

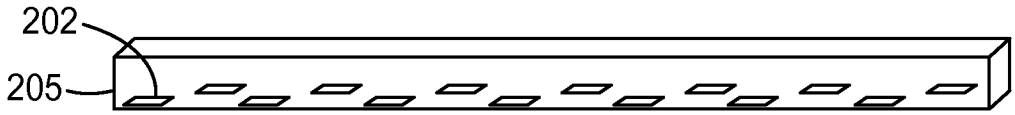

FIG. 5D

FIG. 5E

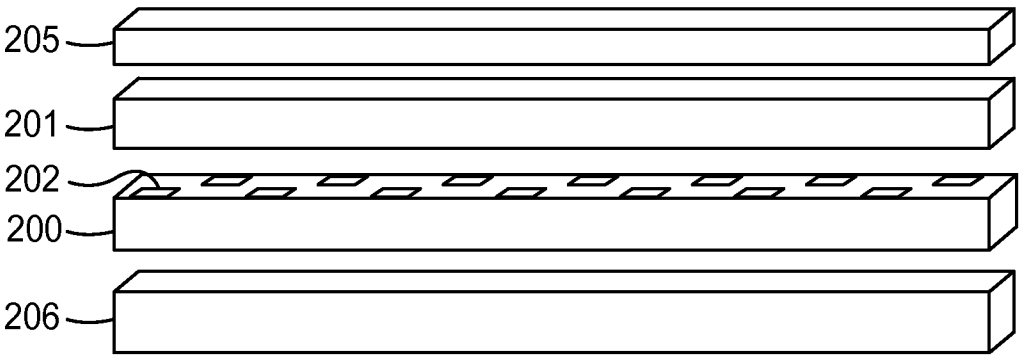

FIG. 5F

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/065583

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/03
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 1 016 547 A1 (RICOH KK [JP]) 5 July 2000 (2000-07-05) paragraph [0014] - paragraph [0019] paragraph [0024] paragraph [0032] - paragraph [0042] paragraph [0055] - paragraph [0056] paragraph [0061] paragraph [0065] - paragraph [0069] claims 1,22-32 figures -----	1-4,6, 8-10 5,7
Y	EP 2 479 650 A1 (ANOTO AB [SE]) 25 July 2012 (2012-07-25) paragraph [0006] paragraph [0013] - paragraph [0014] paragraph [0017] paragraph [0034] -----	5,7

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 February 2014	24/02/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Königer, Axel

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/065583

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No
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